September 28, 1999

Project Information

04-CC,SOL-80
04-043933
Carquinez Bridge
Br. No. 23-0015R

Subject

Review of Pile Driving System Submittal (Third Submittal)

Introduction

This report presents a review of a pile driving system submittal prepared by Goble Rausche Likins and Associates (GRL) dated September 13, 1999. A pile driving system submittal is required for the above referenced project per Section 10-1.35, "PILING", of the Special Provisions. The pile driving contractor has proposed the use of the ICE 220-SH single action hydraulic hammer to drive 48-inch diameter permanent pile casings to specified tip. Characteristics of this hammer include a rated energy of 88 kip-ft at a stroke of 4 feet and a 22 kip ram weight. A submittal for using an ICE 160-SH Hammer at Pier 5 was previously reviewed and approved by this Office in a report dated December 22, 1998.

Foundation Description

The Carquinez Bridge Seismic Retrofit includes the installation of 48-inch diameter Cast-in-drilled-hole (CIDH) concrete piles with permanent steel casings. The CIDH piles will be installed at Pier 5 to a specified tip elevation of -42.0 feet and a cutoff elevation of 1.25 feet. The permanent casings will be driven to a maximum tip elevation of -32.0 feet. The tip elevations of the CIDH piles are controlled by axial loads of 1100 kips in compression and 550 kips in tension.

The nearest geotechnical borings of sufficient depth to Pier 5 on the A4E line appear to be Borings B-4H and B-3H, completed in January 1954 by the State of California Division of Highways. The soil indicated by boring logs in the vicinity of Pier 5 between the ground elevation of -1 feet and -15.0 feet is indicated to be primarily very soft blue-black clay with some silt, sand or gravel present. Underlying the clay, at an elevation of -17 to -19 feet, the soil logs indicate a layer of stiff grey sandy clay. Below the sandy clay is shale, described in one boring at the footing as hard to very hard. The Standard penetration blow counts increase with depth, reaching over 100 per foot by elevation -28 feet at one boring.

Submittal

The driving system analysis submitted by the Contractor consists of the input and output of the GRLWEAP wave equation analysis program Version 1997-2 with accompanying written discussion of assumptions made and program results. The static soil resistance profiles for the various piles are estimated using the American Petroleum Institute (API) method. Fixed soil plugs are not expected to form during driving. Accordingly, the surface areas of the piles are increased by 50 percent to account for the additional resistance resulting from internal skin friction. Each pile size was evaluated twice: once with reduced soil strengths consistent with continuous driving (pre set-up), and once with the maximum soil strengths expected if driving were interrupted for extended time periods (full set-up).

Given these considerations, the analyses predict a minimum penetration rate of 53 blows per foot during driving, at a setup of 0.5, and 120 blows per foot for full setup conditions. Pile stresses are not expected to exceed 23 ksi (51% of the allowable stress of 45 ksi).

Discussion

The driveability analysis provided is internally accurate. However, it utilizes Boring 96B-37, which is located approximately 250 feet away from the center of Pier 5, instead of Borings B-4H and B-3H, which are located at the perimeter of the footing for Pier 5 on the A4E Line. While the assumption to use 96B-37 may be unconservative, Steve Abe of Goble Rausche Likins has previously indicated that the soil data from the closer borings would not change his driveability analysis or conclusions regarding the proposed driving system. Borings B-4H and B-3H indicate that rock may be encountered at higher elevations than modeled by Steve Abe. Therefore, field measured blow counts may be higher significantly higher at shallower pile depths.

Bogdan Komorniczak, Associate Engineering Geologist with the Office of Materials and Foundations, indicates that Borings B-3H and B-4H are preferable to Boring 96B-37 for developing a soil profile for Pier 5. However, the site appears to have a great deal of variability with respect to geologic conditions. As a result of an underlying shale layer being present, there is a potential for localized yielding of the steel shells, especially if non-uniform loading of the pile at tip were to occur. Additionally, as sloping of the top of the shale layer is predicted, vertical penetration by the pile of the layer may pose difficulty.

Recommendations

As the hammer selected by the Contractor is not anticipated to cause any damage to the piles, and as the driveability analysis indicates that an adequate rate of penetration will be obtained, this Office recommends acceptance of the ICE 220-SH hydraulic hammer for pile driving operations at Pier 5. If the hammer cannot drive the piles to the specified tip elevation, and pile dynamic monitoring indicates that the piles are not overstressed, the Contractor may be required to provide and utilize a larger hammer.

If you have any questions or comments, please call me at (916) 227-7235 or Calnet 498-7235.

Brian Liebich

BRIAN LIEBICH
Transportation Engineer, Civil
Foundation Testing & Instrumentation Branch
Office of Geotechnical Support

REGISTERED PROFESSIONAL ENGINEER
DANIEL H. SPEER
No. CE 42993
Exp. 3/31/00
CIVIL ENGINEER
STATE OF CALIFORNIA

DANIEL SPEER, P.E.
Senior Materials and Research Engineer
Foundation Testing & Instrumentation Branch
Office of Geotechnical Support

Caltrans

Balfour Beatty Construction, Inc.

Carquinez Bridge Seismic Retrofit Project
P. O. Box 876
Crockett, CA 94525

Contract No. 04-043934 –
District 4 – Route 80
Contra Costa & Solano Co.

Submittal Form

Bridge No. 23-15R
Submittal No.10-1.35-09B
Date:09/15/99

To: State of California Department of Transportation
825 Alfred Noble Drive, Suite b
Hercules, CA 94547

Attention: Mr. Rick Kaufman

We are sending you X Attached, ____ Under separate cover via ____________, the following items:

☐ Shop Drawings ☐ Prints ☐ Plans ☐ Samples ☐ Specifications

☐ Copy of Letter ☐ Change Order ☐ ____________

Item	Date	Copies		Description
1	09/15/99	3		48" Pile Casing Driving System / Wave Equation Analysis – Revision 2
				RECEIVED SEP 15 1999 CALTRANS HERCULES CONSTRUCTION

These are transmitted as indicated below:

☑ For approval
☐ As requested
☐ (Other)____________

☐ For your use
☐ For review and comment

Remarks:

CT SUB # 44 REVISION 2

FILE # 58.94.01

K. SANDVIK

Copy to: ____________

Signed: ____________
For Balfour Beatty Construction, Inc.

5.04.1

~~001853~~

GRL

Goble Rausche Likins and Associates, Inc.

RECEIVED
SEP 15 1999
CALTRANS
HERCULES CONSTRUCTION

September 11, 1999

Mr. Dennis Bruni
600 Walnut Avenue
Vallejo, California 94592

Re: Wave Equation Analysis / Driving System Submittal
Caltrans- Seismic Retrofit Project 611
Carquinez Bridge

GRL Job No. 988046-1

Dear Mr. Crawley,

This report presents the results of the pile driveability analysis for the above referenced project. Per project specifications, we have performed wave equation analysis for driving the 48-inch CIDH (Cast in Drilled Hole) steel casings at Pier 5. The specifications require that the proposed pile driving system be capable of driving the casings to the specified tip elevation without with driving stresses not more than 95% of the casing yield strength. The casings will be drilled out and socketed into rock after driving. Bearing capacity will be mainly provided by the concrete core and rock socket. Therefore, no bearing capacity or penetration resistance limitations were specified for driving the casings.

Driveability analyses were performed using the GRLWEAP wave equation analysis program. First a static soil resistance profile was computed using the available soil boring data. This soil resistance profile was used as input in the GRLWEAP program to perform a depth analysis.
Results of the depth analysis included estimates of penetration resistance (blow counts), static soil resistance, and driving stresses for various pile tip elevations. The GRLWEAP™ program, Version 1.9987-2, was used for the analyses as is described in Appendix A.

Casing Details

The casing analyzed was a 48-inch O.D. x 1.0-inch wall steel shell with a length of 33.25 ft and a nominal cross sectional area of 148 square inches. The project specifications require that the steel casings conform to the specifications of ASTM Designation A252 grade 3 steel, having a minimum yield strength of 45 ksi. Therefore, the maximum allowable driving stress based on 95% of the yield strength is 42.8 ksi. The pile data table from the plans indicates that the specified pile cut-off and casing tip elevations are +1.25 ft and -32.00 ft respectively.

Driving System / Hammer:

The hammer analyzed for driving the casings was an ICE model 220-SH single acting hydraulic hammer. This hammer has a maximum rated energy of 88.0 kip-ft, a ram weight of 22.0 kips, and a maximum rated stroke of 4.0 ft. A copy of the hammer data form, provided by the hammer supplier, is included in Appendix A. A hammer efficiency of 95% was used for the analyses. The following hammer impact assembly parameters were used for the analyses.

Helmet Weight Analyzed: 10.3 kips

Hammer Cushion: MC904P Blue Nylon; Thickness- 4.0 inches; Cross Sectional Area- 707 in^2 ; Elastic Modulus- 175 ksi.

Soil Conditions and Soil Resistance to Driving

Soil boring log 96B-37 was provided in the project plans and was used to estimate the soil resistance to driving. This boring indicates that subsurface conditions at Pier 5 consist primarily of soft silty clay and clayey silt (Bay Mud) extending to approximately elevation -18 ft. The Bay Mud is underlain by harder silty clay to elevation -27 ft. The boring log also indicates that the hard silty clay transitions to Claystone rock at about elevation -30 ft. The boring indicates that the claystone is highly fractured and decomposed at the specified casing tip elevation and has an SPT blow count of 107 blows/ft. Copies of the soil boring logs are included in Appendix B.

SRD (Soil Resistance to Driving) profiles for input in the GRLWEAP driveability analyses were estimated from the available soil data using static pile analysis procedures recommended by the American Petroleum Institute, API RP 2A Design Code. The SRD work sheets and copies of the soil boring logs are included in Appendix B.

For the depth analyses, shaft friction gain/ loss factors of 0.5 and 1.0 were analyzed to represent pre set-up (0.5 SRD) and full set-up (1.0 SRD) conditions respectively. The pre set-up analyses estimate the expected SRD condition under continuous driving conditions. The full set-up SRD conditions would be expected only if a long delay to driving occurred. For all analyses it was assumed that a soil plug would not develop during driving. It was further estimated that 50% of the external shaft resistance would additionally act inside the casing during driving. To model this condition if GRLWEAP, a pile circumference of 1.5 times the external casing circumference was input for the pile model. The following dynamic soil parameters were used for all GRLWEAP Analyses.

GRLWEAP Soil Resistance Parameters:

The following soil parameters were input to model the dynamic soil behavior.

Shaft Quake = 0.10 inches;
Toe Quake= 0.40 inches
Shaft Damping= 0.20 s/ft
Toe Damping= 0.15 s/ft

ANALYSIS RESULTS

The driveability depth analysis results are presented in Table 1 and are plotted as Figures 1 and 2 for pre-setup and full setup soil resistance cases respectively. Complete analysis output is included as Appendix C. The analysis results for pre set-up SRD profile predicted that the ICE 220-SH hammer can drive the casing to the specified tip elevation of -32 ft with penetration resistance of 53 blows/ft and a maximum SRD of 1000 kips.

The analysis for the full setup soil resistance predicted a worst case driving resistance at the specified tip elevation of 120 blows/ft for a estimated soil resistance of 1,836 kips. This worst case driving resistance would only be expected if a long interruption to driving occurred below tip elevation -25 ft. The maximum computed driving stresses from either analysis were less than 23 ksi and are within the specified limits in the project specifications.

Limitations of The Analyses

The GRLWEAP program simulates the behavior of an impact driven pile. The program contains mathematical models which describe hammer, driving system, pile and soil during the hammer blow. Under certain conditions, the models only crudely approximate often complex dynamic situations.

Please note that the driving stresses calculated by the wave equation are axial stresses assuming ideal, uniform hammer impacts. The analysis does not consider higher stresses which could be induced by bending, non-axial hammer alignment, or high local stress concentrations, and therefore should be considered as minimum values. Furthermore, tip damage of open-end pipe piles is not uncommon due to localized stresses in the pile wall. Local stresses can greatly exceed the uniform axial stresses at the pile tip due to non-uniform tip resistance, even if axial stresses are within the allowable limits. We recommend good axial hammer pile alignment be maintained during driving to reduce the possibility of these higher stresses.

The results calculated by the wave equation analysis program depend on a variety of hammer, pile and soil input assumptions. Although attempts have been made to base the analysis on the best available information, actual field conditions may differ greatly from the assumed conditions. Therefore, hammer and pile performance may differ greatly from the predictions reported.

We recommend prudent use of GRLWEAP results. Suitability of driving equipment or pile acceptance criteria should never be based solely on wave equation analysis results. Rather, the actual soil response, hammer performance, and driving stresses should be verified by dynamic measurements.

We appreciate the opportunity to be of assistance to you on this project. Please contact our office if you have any questions regarding this report.

Very truly yours,

GOBLE RAUSCHE LIKINS & ASSOCIATES, INC.

Steve Abe

Steve Abe, P.E.

REGISTERED PROFESSIONAL ENGINEER
STEVEN K. ABE
No. C 055277
Exp. 12/31/2000
CIVIL
STATE OF CALIFORNIA

T~ble 1: GRLWEAP Results- Carruinez Bridge, Pier 5, ICE 220 SH

Pre set-up SRD- Shaft/Toe Gain/Loss Factor .500/ 1.030

Depth feet	Ultimate Capacity kips	Shaft Resistance kips	End Bearing kips	Blow Count bl/ft	Max C. Stress ksi	Max T. Stress ksi	Blow Rate bpm	ENTHRU kip-ft
10.0	.0	.0	.0	.0	.000	.000	.0	.0
15.0	16.7	14.6	2.2	1.7	22.160	15.590	60.0	71.7
20.0	114.2	82.7	31.4	5.0	22.231	12.920	60.0	76.0
25.0	346.2	245.7	100.5	15.9	22.233	7.607	60.0	75.1
30.0	805.0	635.5	169.5	41.2	22.302	1.852	60.0	75.0
32.0	999.4	818.2	181.2	53.2	22.329	1.832	60.0	75.0

Total Driving Time 5.11 min. for 60.0 bl/min; Total No. of Blows 306

Blow Rate:	50 bl/min	40 bl/min	30 bl/min
Total Driving Time:	6.13 min	7.66 min	10.22 min

Drive time for continuously running hammer; any waiting times not included

Full set-up SRD- Shaft/Toe Gain/Loss Factor 1.000/ 1.030

Depth feet	Ultimate Capacity kips	Shaft Resistance kips	End Bearing kips	Blow Count bl/ft	Max C. Stress ksi	Max T. Stress ksi	Blow Rate bpm	ENTHRU kip-ft
10.0	.0	.0	.0	.0	.000	.000	.0	.0
15.0	58.5	54.5	4.0	2.8	22.162	14.344	60.0	72.2
20.0	217.1	182.4	34.7	9.6	22.355	10.010	60.0	75.9
25.0	610.5	506.8	103.7	29.3	22.332	2.146	60.0	75.2
30.0	1458.6	1287.0	171.6	81.3	22.470	2.561	60.0	72.8
32.0	1836.4	1653.3	183.1	120.0	22.728	3.474	60.0	71.4

Total Driving Time 10.11 min. for 60.0 bl/min; Total No. of Blows 606

Blow Rate:	50 bl/min	40 bl/min	30 bl/min
Total Driving Time:	12.13 min	15.16 min	20.22 min

Drive time for continuously running hammer; any waiting times not included

Carruinez Bridge, Pier 5, ICE 220 SH 0?/11/99

Goble Rausche Likins & Associates, Inc. Shaft/Toe G/L .500 / 1.030 GRLWEAP(TM) Version 1997-2

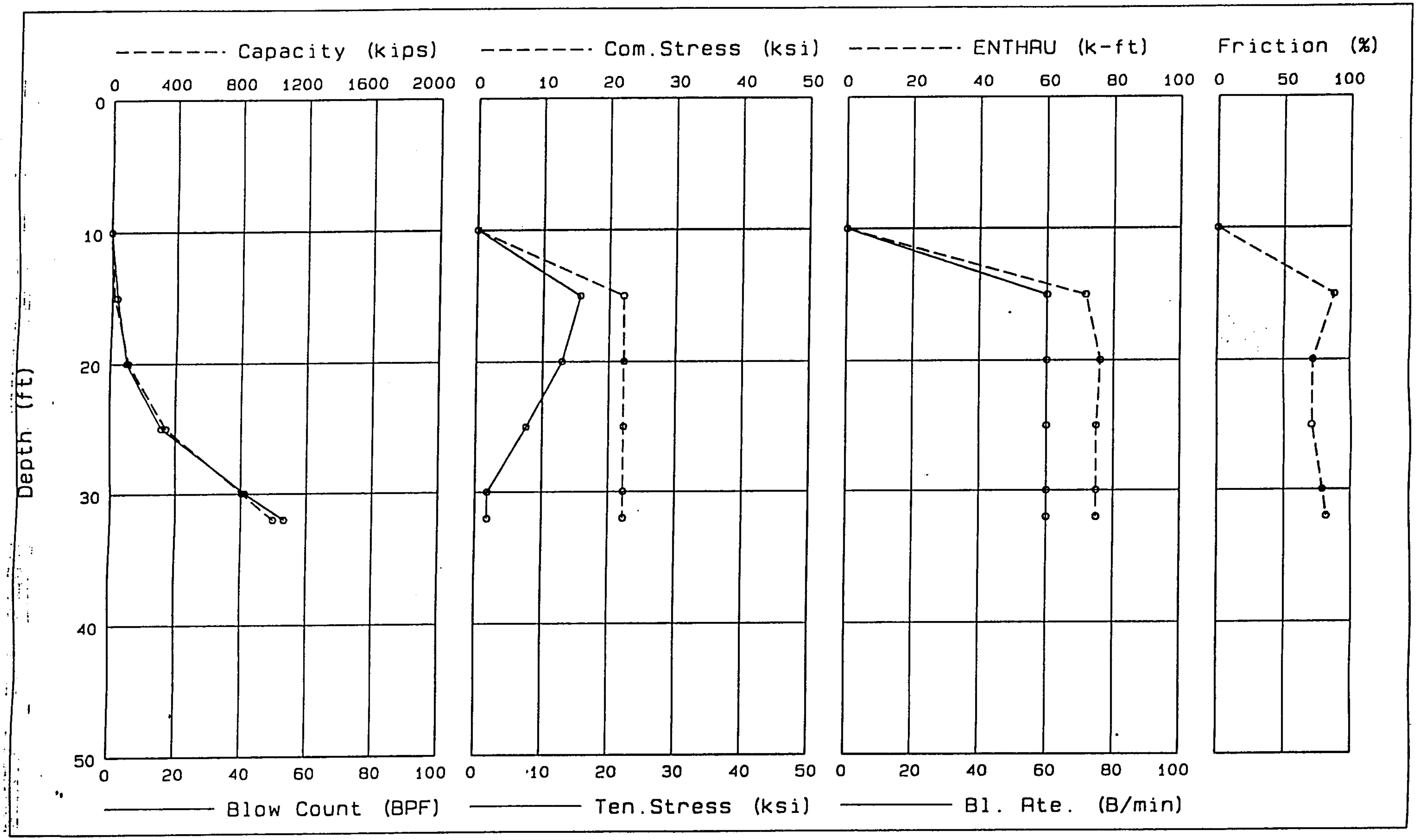


Figure 1: Pre-setup soil resistance

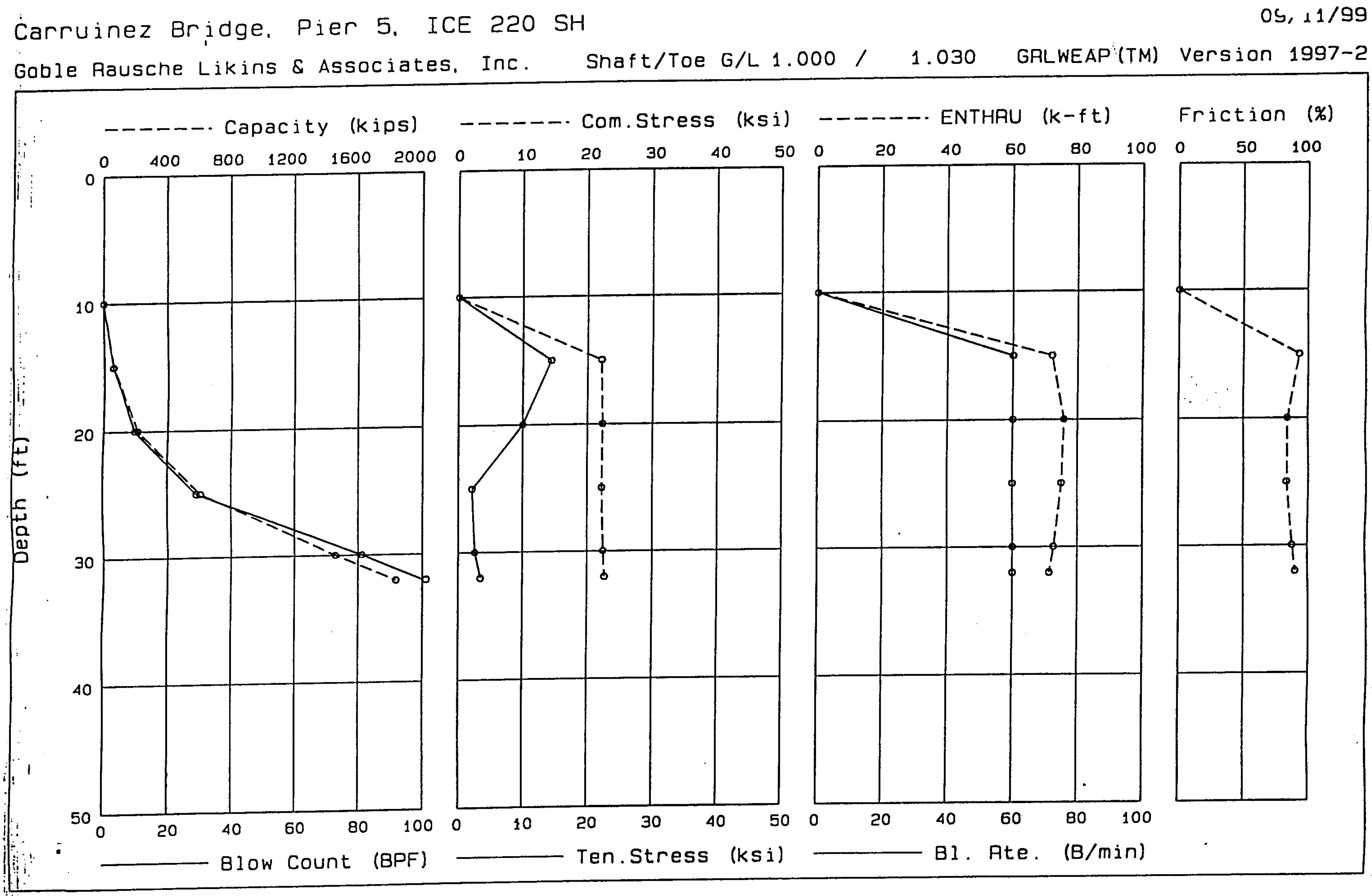


Figure 2: Full setup soil resistance

APPENDIX A

-GRLWEAP Program Description-

-Hammer Data Form-

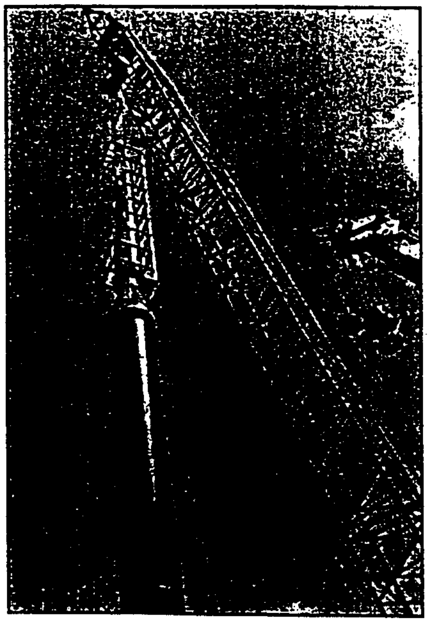
GRLWEAP™: Wave Equation Analysis of Pile Driving

Software For Dynamic Pile Analysis by Goble Rausche Likins and Associates, Inc.

Background

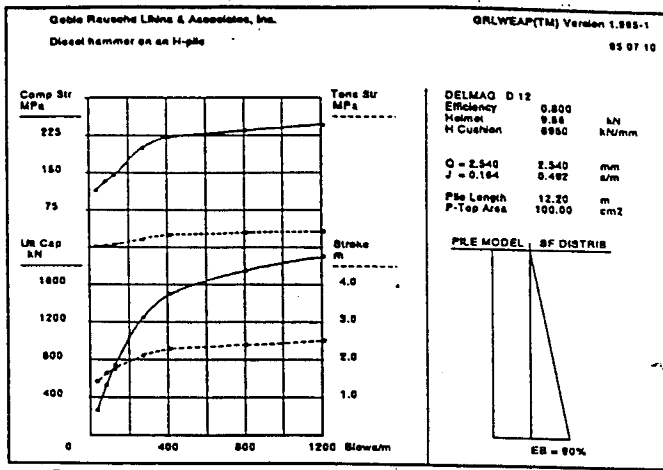
Since its introduction in 1988, GRLWEAP (which is based on the WEAP program of 1976) has achieved wide popularity throughout the world. The program simulates the behavior of a pile (a slender elastic rod) and the surrounding soil (an elastic-plastic and viscous material) under the impact of a pile driving hammer. Powerful options combine the basic analysis of one hammer blow into the simulation of a complete pile driving process.

Today the GRLWEAP software is recognized by many specifying agencies as the most reliable predictor of dynamic pile driving stresses, hammer performance, and either blow count or bearing capacity of an impact driven pile.

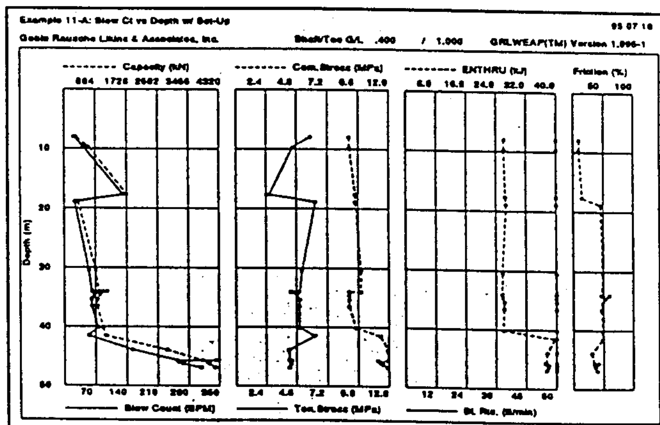


Among GRLWEAP's time saving options are

- Plotting or screen graphic display of results.
- Extensive help files including nearly 400 hammer models and associated driving system components.
- Automatic model generation.
- Simple input/ output file management.
- Screen display of analysis results in numerical or graphic form.



Bearing Graph - Capacity, Stresses and Stroke *vs.* Blow Count



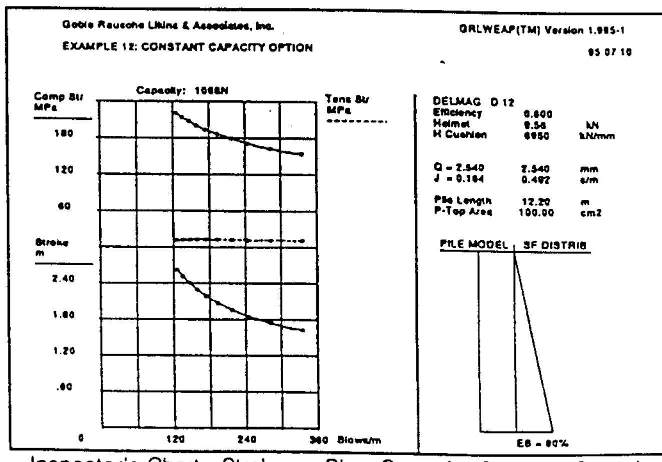
Driveability - Capacity, Blow Count and Stresses *vs.* Depth

GRLWEAP analysis options include

- Bearing graph: capacity and stress maxima *vs* blow count.
- Driveability analysis: blow count and stresses *vs.* depth allowing for consideration of variable pile length, loss of soil set-up, cushion deterioration and others.
- Inspector's Chart: required blow count for variable stroke (energy) and fixed bearing capacity.
- Residual stresses for improved realism of simulation.
- Vibratory hammer analysis.
- Double pile analysis (*e.g.*, mandrel driven piles).
- Variable (program calculated) or constant stroke analysis for diesel hammers.
- Bounce chamber pressure for closed end diesel hammers.
- Atomized or liquid fuel injection for diesel hammers.
- SI or English units.

Numerical Process

- Diesel hammers with thermodynamic analysis.
- Smith-type lumped mass hammer and pile model with Newmark β-method and predictor-corrector type analysis.
- Non-linear/bilinear stress-strain analysis of slacks, splices, cushions and other material interfaces.
- Up to 498 pile segments for realistic analysis of piles with up to 500 m length.
- Smith type soil model with four additional soil damping options.
- Soil model extensions (for research applications) for soil plug, radiation damping among others.

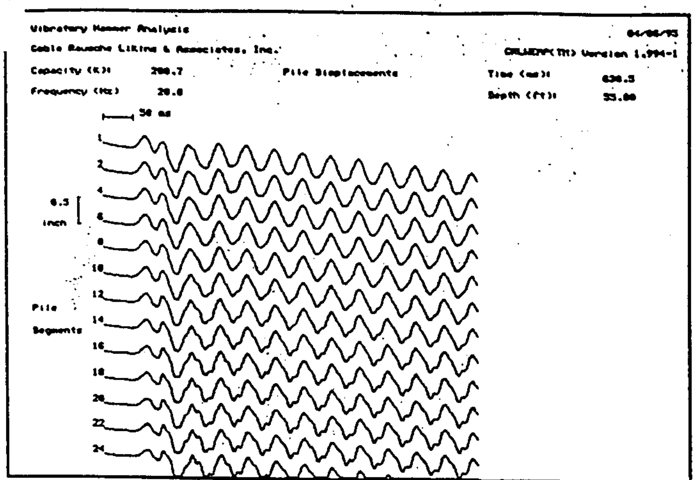


Inspector's Chart - Stroke *vs.* Blow Count for Constant Capacity

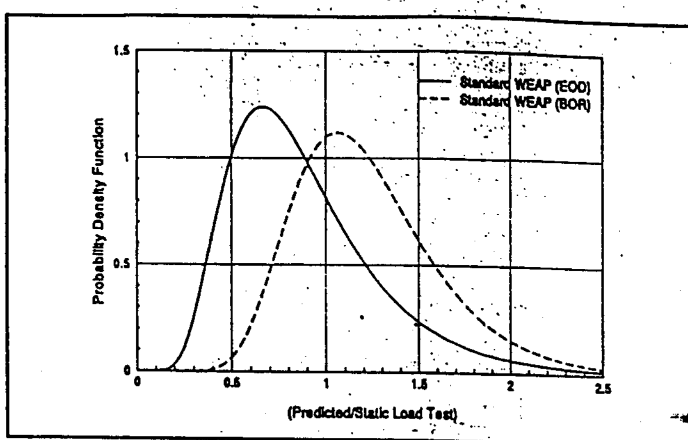
GRLIMAGE

This wave equation demonstration program, an integral part of GRLWEAP, aids in understanding what happens to a pile after it has been struck by a mass. The program allows for variation of parameters such as pile length, cushion stiffness, ram fall height, cross sectional area and ultimate resistance. It illustrates the concepts of dynamic wave propagation, soil resistance activation, residual stresses, *etc.*

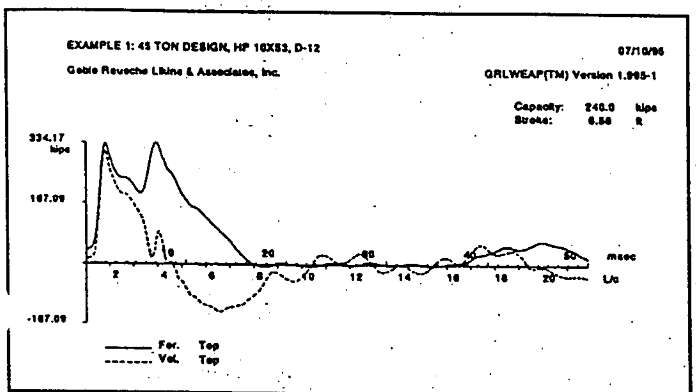
Goble Rausche Likins and Associates, Inc. Software: GRLWEAP™



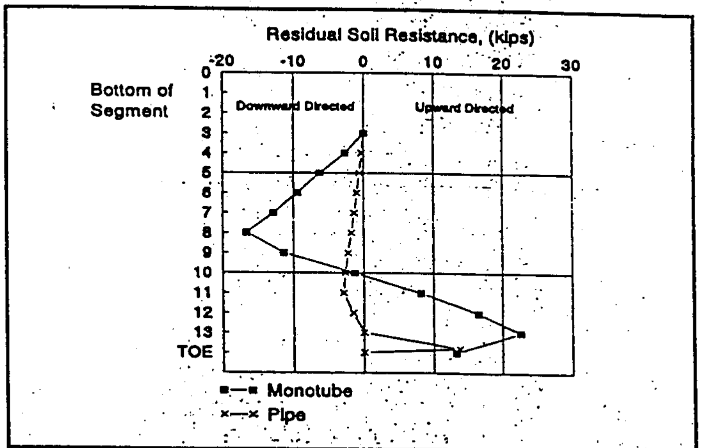
Screen Display of Vibratory Hammer Analysis



Statistical Evaluation of Bearing Capacity Prediction



Force and Velocity Calculated for a Diesel Driven Pile



Graphical Representation of Calculated Residual Forces in Soil

Program performance and verification
GRL used its large data base containing dynamic and static load test results for extensive correlations. In addition, many studies published on the accuracy of wave equation pre-dictions generally indicate that pile top stresses are predicted within 10 to 15% of measured values unless actual hammer or driving system performance is unusual.

Bearing capacity predictions are complicated by time effects on the soil resistance which often increases after pile installation. Thus, bearing capacity predictions based on End-of-Driving (EOD) blow counts may be lower than static load test results (see the above statistical summary showing probability density vs. the ratio of wave equation predicted capacity to static test load). Predictions can be improved using the set-up factors or beginning of restrike (BOR) blow counts. Unfortunately, since energy and capacity variations typically occur during restriking, predicted capacities are less precise for BOR than EOD based values, but practically without bias against either overprediction or underprediction. Sometimes predictions can also be improved using Residual Stress Analysis (see the figure of calculated forces locked in the soil after a hammer blow). However, GRL strongly recommends static load tests and/or dynamic tests by the Pile Driving Analyzer® for result verification.

Prior to a new release, program performance and code quality is checked by the analysis of a large number of examples. Results are compared with earlier versions and/or known values. The program then undergoes a testing phase by GRL's civil and geotechnical engineers.

Windows compatibility
GRLWEAP has not been written for the Windows environment and hence is not a so-called Windows version. However, the program does run under Windows as a DOS application.

Support for Registered Users
Regular updating service and answering of questions is standard GRL policy. These questions may concern program installation, software operation and, to a limited degree, civil engineering application. Users can renew their support registration on a yearly basis.

Hardware requirements
GRLWEAP runs on IBM-PC or compatible computers. It requires DOS 3.3 or higher and a hard drive. A math coprocessor and/or a 486DX machine, or better, are highly recommended for faster analysis execution. The program supports EGA and VGA monitors, a number of laser printers and a variety of inkjet and dot matrix printers. Graphics plotting can be done through HP 7400 series plotters or printers with HPGL adapters.

GRL
Goble Rausche Likins and Associates, Inc.
4535 Emery Industrial Parkway
Cleveland, Ohio 44128 USA
Phone: 216 831 6131 Fax: 216 831 0916
E-Mail: Info@pile.com

ICE Model 220 Hydraulic Impact Hammer

Specifications

Hammer	Ram weight	22,000 lbs. (9979 kg)
	Maximum stroke	4 ft. (1.2 meters)
	Rated energy @ maximum stroke	88,000 ft-lbs. (118 kJ)
	Blow rate @ maximum stroke	40 bpm
	Minimum stroke	1.5 ft. (0.45 m)
	Blow rate @ minimum stroke	60 bpm
	Hammer weight[1]	34,600 lbs. (15694 kg)
	Complete operating weight[2]	40,995 lbs. (18595 kg)
	Length (bare)	20' - 3" (6172 mm)
	Complete operating length with cap[2]	22'- 10" (6960 mm)
	Width	32 in. (813mm)
	Depth	48 in. (1219 mm)
	Hydraulic hose length	100 ft. (30 m)
	Hydraulic hose weight	1,340 lbs. (608 kg)

[1]Includes 32 in. lead guides, without hoses
[2]Includes hoses, striker plate, drive cap and 18 in. concrete insert

Power Unit	Designation	ICE Model 325
	Engine	CAT 3306TA
	Power	325 HP (242 kW)
	Operating speed	2100 rpm
	Drive pressure	5,000 psi (345 bar)
	Drive flow	87 gpm (329 lpm)
	Stroke control pressure	1,000 psi (70 bar)
	Stroke control flow	5.2 gpm (20 lpm)
	Weight[1]	10,485 lbs. (4756 kg)
	Length	126 in. (3200 mm)
	Width	60 in. (1520 mm)
	Height	79 in. (2010 mm)

[1]Weight includes full fluid and fuel.

301 Warehouse Dr., Matthews, NC 28104 • 888-ICEUSA1 (423-8721) or 704-821-8200, Fax 704-821-8201 • www.iceusa.com

CALIFORNIA DEPARTMENT OF TRANSPORTATION
OFFICE OF TRANSPORTATION LABORATORY

PILE AND DRIVING DATA FORM

Structure Name: CARQUINEZ BRIDGE Contract No.: 04-043934
A4E LNG (MAIN SPAN)
Structure No.: PILE NO. 5 Project: CARQUINEZ BRIDGE
Dist./Co./Rte./P.M.: CONTRA COSTA Pile Driving Contractor or Subcontractor: BALFOUR BEATTY
(Pile Driven By)

Hammer (Ram, Anvil)

Manufacturer: ICE Model: 220
Type: SINGLE ACTING HYDRAULIC Serial No.:
Rated Energy: 88,000 ft-lbs 4'-0" Length of Stroke
Modifications: N/A

Capblock (Hammer Cushion)

Material: MC904P PLASTICIZED BLUE NYLON
Thickness: 4.0" Area: 707.0 IN²
Modulus of Elasticity - E: 175,000 (P.S.I.)
Coefficient of Restitution - e: 0.92

Pile Cap (Helmet / Bonnet / Anvil Block / Drivehead)

DHP-48 / STRIKER PLATE / CUSHION
Weight: 10,300 lbs

Pile Cushion

Material: N/A
Thickness: Area:
Modulus of Elasticity - E: (P.S.I.)
Coefficient of Restitution - e:

Pile

Pile Type: 48" I.D. OPEN-ENDED PIPE PILE
Length (In Leads): 33'-3" LONG
Weight/ft.: 523 lbs/ft Taper:
Wall Thickness: 1.0 INCHES
Cross Sectional Area: 153.9 sq.in.
Design Pile Capacity: (Tons)
Description of Splice:

Tip Treatment Description:

DISTRIBUTION
One Copy Each To:
- ☐ Translab Geotechnical Engineering
- ☐ Translab Engineering Geology
- ☐ Resident Engineer

Note: If mandrel is used to drive the pile, attach separate manufacturer's detail sheet(s) including weight and dimensions.

Submitted By: ______ Date: ______

Phone No.: ______

PILE & DRIVING DATA FORM

18

APPENDIX B

-Soil Borings and SRD Worksheet-

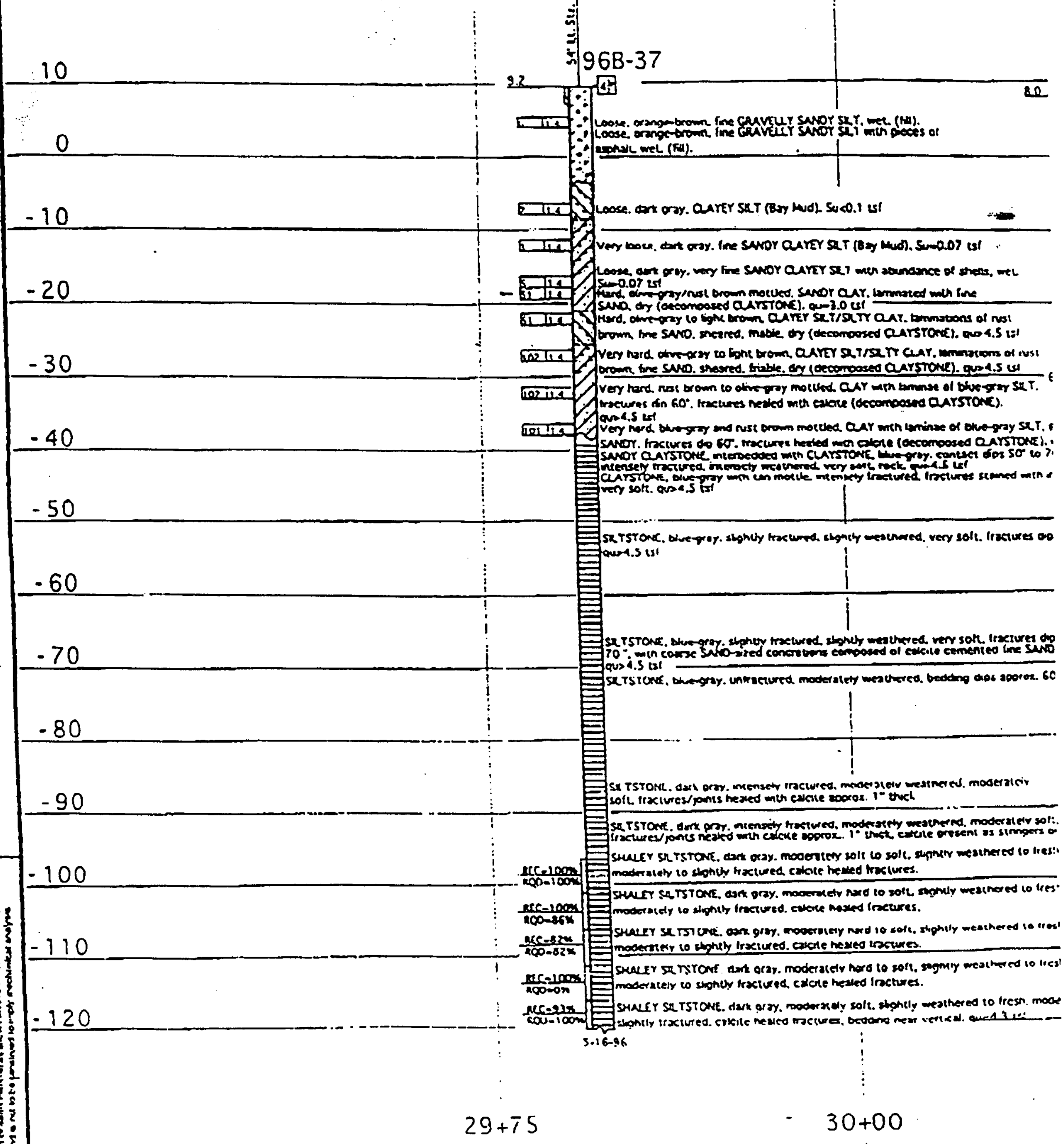
BENCH MARK

ELEVATIONS TAKEN FROM THE CONTOUR MAP (96B-4 & 96B-42).

DN-712 ELEV. 49.34

PK NAIL C.L CALTRANS WASHER IN 12 FT. PAINTED TGT IN PARKING LOT JUST BEHIND EAST OF C & H CO. BUILDING 33.8 FT. NORTH OF FIRE HYDRANT

FOR PLAN VIEW, SEE "LOG OF TEST BORIN



ENGINEERING SERVICE CENTER	STRUCTURE FOUNDATIONS	FIELD INVESTIGATION BY: Amaru and Jensen; Reviewed By: Koniomczak	CALI... DEPARTMENT O...
DRAWN BY	7/96		

GLR Static Capacity Analysis Worksheet for GRLWEAP Input

Project Name: Carquinez Strait Bridge

Analysis Description: Pier 5
48 Inch CIDH

Recommended Delta			Recommended K			
Materi	Factor		SoilTyp		Kc	Kt
steel	0.67-0.8		SAND		0.8-1.0	0.8-1.0
concre	0.90-1.0		SILT		1.0	0.5- 0.7
timber	0.8-1.0		CLAY		1.0	0.7- 1.0

OD (in)	48	T wall	1.00	T tip	1.00
Pile Area in^2	147.7	Soil Boring Surface Eleva	10	K FACTOR	1
Shaft Area ft**2/f	12.57	Surface Elevation (Drivin	1.25	DELTA FACTOR	0.80
Toe Area ft**2	1.03	Excavation Depth	9	Int. Friction Facto	0.50
Water Depth ft	1.25	Required Tip Elevation	-32	Toe factor	1.00
Surcharge ksf	0	Pile Length For BG	33.25		
		Final Penetration (For BG	33.25		

Critical Depth 70

Depth of water table 0

SOIL BORING DATA				SOIL PARAMETERS			COHESIVE SOIL		NON-COHESI	
Sand=1 Silt=2 Clay=3	Depth Penet. ft	Tip Elev. ft	SPT N Field BPF	SPT N Correc BPF	Unit Wt psf	Effecti Stress ksf	Shr Sth. Su ksf	Alpha %	Phi	TOE COEF. Nq
2	0	1.25	1	2	79	0.00	0.20	1.00	44	145
2	21.25	-20	5	6	97	0.54	0.20	1.00	42	115
3	21.25	-20	51	51	140	1.00	3.00	0.38	38	NA
3	33.25	-32	107	107	140	1.93	4.50	0.40	39	NA
3	41.25	-40	107	107	140	2.55	5.00	0.42	39	NA

Soil Resistance Parameters For GRLWEAP Input

GRLWEAP SOIL PROFILE						STATIC CAPACITY		
DA Elev. ft	Unit Friction ksf	Unit Frictio Kpa	Toe Bearing ksf	Toe Bearin Kpa	Skin Dampin s/ft	SUM FRICTIO Kips	TOE BEARING KIPS	Total Capacity Kips
0	0.20	1	5	239	0.10	0	5	5
-12	0.56	27	62	2953	0.10	151	63	215
-12	1.72	83	27	1293	0.20	385	28	413
-24	2.99	143	41	1939	0.20	918	42	960
-32	3.66	175	45	2155	0.20	1419	46	1465

APPENDIX C

-GRLWEAP Analysis Input and Output-

```
Input  File: C:\1SEND\ICE220.GWI
Hammer File: HAMMER.ALT
```

Echo Print of Input Data

```
   Carruinez Bridge, Pier 5, ICE 220 SH
100    0 554   0   0    0   0    0   0   1    0   0    0   0    0   0    0
   10.300   707.000        175.0      4.000        .920        .010         .0         .000
    .000         .0         .000       .500        .010          .0
   33.250   147.660 30000.000     492.000      18.900      45.000        .850         .010
ICE      220-SH       3    2    0
    22.00      69.50       62.62     4.0000      1.0000       .9500      .0000
      .00        .00        .800       .010      2
    6.300      6.300        .000    23900.0     23900.0          .0
    .0000      .0000       .0000      .0000       .0000       .0000       .0000       .0000
     .100       .400        .200       .150        .000        .000        .000        .000
     .000       .000        .000       .000
     .000       .000        .000       .000
      .00       .25      2.00        .00        .00        .00        .00        .00        .00        .00
    15.00       .34      6.00        .00        .00        .00        .00        .00        .00        .00
    17.00      1.15     19.00        .00        .00        .00        .00        .00        .00        .00
    23.00      3.19     57.00        .00        .00        .00        .00        .00        .00        .00
    27.00      8.50    153.00        .00        .00        .00        .00        .00        .00        .00
    32.00     10.00    180.00        .00        .00        .00        .00        .00        .00        .00
    33.25     10.00    180.00        .00        .00        .00        .00        .00        .00        .00
     .500     1.000      .000       .000       .000       .000       .000       .000       .000       .000
    1.030     1.030      .000       .000       .000       .000       .000       .000       .000       .000
    10.00        .00        .00       .000        .000        .000        .000        .000
    15.00        .00        .00       .000        .000        .000        .000        .000
    20.00        .00        .00       .000        .000        .000        .000        .000
    25.00        .00        .00       .000        .000        .000        .000        .000
    30.00        .00        .00       .000        .000        .000        .000        .000
    32.00        .00        .00       .000        .000        .000        .000        .000
      .00        .00        .00       .000        .000        .000        .000        .000
```

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of an impact driven pile. The program contains mathematical models which describe hammer, driving system, pile and soil during the hammer blow. Under certain conditions, the models only crudely approximate often complex dynamic situations.

A wave equation analysis also relies on input data which represents normal situations. The data may be the best available information at the time of the analysis, however, it may greatly differ from actual field conditions.

The program authors, therefore, recommend prudent use of GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic measurements. Estimates of bending or other local non-axial stresses and prestress effects must also be accounted for by the user.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of a safety factor to yield a design or working load.

```
Analysis Skipped- -Dead Load exceeds Ru:        33.0     31.3
```

GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS SHORT PILE VERSION
Version 1997-2
English Units

Carruinez Bridge, Pier 5, ICE 220 SH

Hammer Model: 220-SH Made by: ICE

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	11.000				
2	11.000	2570155.0	1.000	.0100	
Helmet	10.300	30563.4	.920	.0100	14.2

Assembly	Weight kips	Stiffn k/inch	CoR	C-Slk ft
1	6.300	23900.0		
2	6.300	23900.0	.800	.0100

HAMMER OPTIONS:

Hammer File ID No.	554	Hammer Type	3
Stroke Option	0	Hammer Damping	2

HAMMER DATA:

Ram Weight	(kips)	22.00	Ram Length	(inch)	69.50
Maximum Stroke	(ft)	4.00	Actual Stroke	(ft)	4.00
			Efficiency		.950
Maximum Energy	(kip-ft)	88.00	Potential Energy	(kip-ft)	88.00
Kinetic Energy	(kip-ft)	83.60	Impact Velocity	(ft/s)	15.64
HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	707.00	Cross Sect. Area	(in2)	.00
Elastic-Modulus	(ksi)	175.0	Elastic-Modulus	(ksi)	.0
Thickness	(inch)	4.00	Thickness	(inch)	.00
Coeff of Restitution		.9	Coeff of Restitution		.5
RoundOut	(ft)	.0	RoundOut	(ft)	.0
Stiffness	(kips/in)	30931.3	Stiffness	(kips/in)	.0

Depth	(ft)	10.0	Dead Load	(kips)	32.96
Shaft Gain/Loss Factor		.500	Toe Gain/Loss Factor		1.030

PILE PROFILE:

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Circmf ft	Strength ksi	Wave Sp ft/s	EA/c k/ft/s
.0	147.66	30000.	492.0	18.9	45.000	16807.	263.6
33.3	147.66	30000.	492.0	18.9	45.000	16807.	263.6

Wave Travel Time 2L/c (ms) 3.957

Pile and Soil Model — Total Capacity Rut (kips) -1.7

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Circmf ft	Area in2
1	1.677	111023.	.010	.000	.85	.0	.000	.100	3.33	18.9	147.7
2	1.677	111023.	.000	.000	1.00	.0	.000	.100	6.65	18.9	147.7
3	1.677	111023.	.000	.000	1.00	.0	.000	.100	9.98	18.9	147.7
7	1.677	111023.	.000	.000	1.00	.1	.200	.100	23.28	18.9	147.7
8	1.677	111023.	.000	.000	1.00	8.2	.200	.100	26.60	18.9	147.7
9	1.677	111023.	.000	.000	1.00	8.8	.200	.100	29.93	18.9	147.7
10	1.677	111023.	.000	.000	1.00	9.4	.200	.100	33.25	18.9	147.7
Toe						4.8	.150	.400			

PILE, SOIL, ANALYSIS OPTIONS:

Uniform/Non-Uniform/2-Pile	0	Pile Segments: Automatic	
. of Slacks/Splices	0	Pile Damping (%)	1
		Pile Damping Fact.(k/ft/s)	5.271
Drivability Analysis			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Residual Stress Analysis	0	Output Option	0
Output Time Interval	2	Analysis Time-Input (ms)	0
Output Segment Generation	Automatic		

MODIFIED PARAMETERS:

Eq. Stroke	4.00	(ft)	Efficiency	.95
Pile Cushion Stiffn	0.	(k/in)	Pile Cushion CoR	.50

Carruinez Bridge, Pier 5, ICE 220 SH
Goble Rausche Likins & Associates, Inc.

09/11/99
GRLWEAP(TM) Version 1997-2

Depth	(ft)	15.0	Dead Load	(kips)	31.29
Shaft Gain/Loss Factor		.500	Toe Gain/Loss Factor		1.030

PILE PROFILE:

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Circmf ft	Strength ksi	Wave Sp ft/s	EA/c k/ft/s
.0	147.66	30000.	492.0	18.9	45.000	16807.	263.6
33.3	147.66	30000.	492.0	18.9	45.000	16807.	263.6

Wave Travel Time 2L/c (ms) 3.957

Pile and Soil Model — Total Capacity Rut (kips) 16.7

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Circmf ft	Area in2
1	1.677	111023.	.010	.000	.85	.0	.000	.100	3.33	18.9	147.7
2	1.677	111023.	.000	.000	1.00	.0	.000	.100	6.65	18.9	147.7
3	1.677	111023.	.000	.000	1.00	.0	.000	.100	9.98	18.9	147.7
6	1.677	111023.	.000	.000	1.00	1.4	.200	.100	19.95	18.9	147.7
7	1.677	111023.	.000	.000	1.00	3.0	.200	.100	23.28	18.9	147.7
8	1.677	111023.	.000	.000	1.00	3.2	.200	.100	26.60	18.9	147.7
9	1.677	111023.	.000	.000	1.00	3.4	.200	.100	29.93	18.9	147.7
10	1.677	111023.	.000	.000	1.00	3.6	.200	.100	33.25	18.9	147.7
Toe						2.2	.150	.400			

MODIFIED PARAMETERS:

Eq. Stroke	4.00	(ft)	Efficiency	.95
Pile Cushion Stiffn	0.	(k/in)	Pile Cushion CoR	.50

Rut (kips)	Bl Ct (bpf)	Stroke(eq.) (ft)	min Str (ksi)	i,t	max Str (ksi)	i,t	ENTHRU (kip-ft)
16.7	1.7	4.00	-15.59	(4, 7)	22.16	(1, 3)	71.7
58.5	2.8	4.00	-14.34	(4, 7)	22.16	(1, 3)	72.2

Carruinez Bridge, Pier 5, ICE 220 SH 09/11/99
Goble Rausche Likins & Associates, Inc. GRLWEAP(TM) Version 1997-2

Depth	(ft)	20.0	Dead Load	(kips)	27.93
Shaft Gain/Loss Factor		.500	Toe Gain/Loss Factor		1.030

PILE PROFILE:

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Circmf ft	Strength ksi	Wave Sp ft/s	EA/c k/ft/s
.0	147.66	30000.	492.0	18.9	45.000	16807.	263.6
33.3	147.66	30000.	492.0	18.9	45.000	16807.	263.6

Wave Travel Time 2L/c (ms) 3.957

Pile and Soil Model — Total Capacity Rut (kips) 114.2

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Circmf ft	Area in2
1	1.677	111023.	.010	.000	.85	.0	.000	.100	3.33	18.9	147.7
2	1.677	111023.	.000	.000	1.00	.0	.000	.100	6.65	18.9	147.7
3	1.677	111023.	.000	.000	1.00	.0	.000	.100	9.98	18.9	147.7
4	1.677	111023.	.000	.000	1.00	.1	.200	.100	13.30	18.9	147.7
5	1.677	111023.	.000	.000	1.00	6.6	.200	.100	16.63	18.9	147.7
6	1.677	111023.	.000	.000	1.00	7.1	.200	.100	19.95	18.9	147.7
7	1.677	111023.	.000	.000	1.00	7.6	.200	.100	23.28	18.9	147.7
8	1.677	111023.	.000	.000	1.00	8.1	.200	.100	26.60	18.9	147.7
9	1.677	111023.	.000	.000	1.00	12.8	.200	.100	29.93	18.9	147.7
10	1.677	111023.	.000	.000	1.00	40.5	.200	.100	33.25	18.9	147.7
?						31.4	.150	.400			

MODIFIED PARAMETERS:

Eq. Stroke	4.00	(ft)	Efficiency	.95
Pile Cushion Stiffn	0.	(k/in)	Pile Cushion CoR	.50

Rut (kips)	Bl Ct (bpf)	Stroke(eq.) (ft)	min Str (ksi)	i,t	max Str (ksi)	i,t	ENTHRU (kip-ft)
114.2	5.0	4.00	-12.92	(4, 7)	22.23	(5, 4)	76.0
217.1	9.6	4.00	-10.01	(4, 7)	22.36	(5, 4)	75.9

Carruinez Bridge, Pier 5, ICE 220 SH
Goble Rausche Likins & Associates, Inc.

09/11/99
GRLWEAP(TM) Version 1997-2

Depth	(ft)	25.0	Dead Load	(kips)	26.25
Shaft Gain/Loss Factor		.500	Toe Gain/Loss Factor		1.030

PILE PROFILE:

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Circmf ft	Strength ksi	Wave Sp ft/s	EA/c k/ft/s
.0	147.66	30000.	492.0	18.9	45.000	16807.	263.6
33.3	147.66	30000.	492.0	18.9	45.000	16807.	263.6

Wave Travel Time 2L/c (ms) 3.957

Pile and Soil Model — Total Capacity Rut (kips) 346.2

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Circmf ft	Area in2
1	1.677	111023.	.010	.000	.85	.0	.000	.100	3.33	18.9	147.7
2	1.677	111023.	.000	.000	1.00	.0	.000	.100	6.65	18.9	147.7
3	1.677	111023.	.000	.000	1.00	3.9	.200	.100	9.98	18.9	147.7
4	1.677	111023.	.000	.000	1.00	7.9	.200	.100	13.30	18.9	147.7
5	1.677	111023.	.000	.000	1.00	8.5	.200	.100	16.63	18.9	147.7
6	1.677	111023.	.000	.000	1.00	9.1	.200	.100	19.95	18.9	147.7
7	1.677	111023.	.000	.000	1.00	9.6	.200	.100	23.28	18.9	147.7
8	1.677	111023.	.000	.000	1.00	29.4	.200	.100	26.60	18.9	147.7
9	1.677	111023.	.000	.000	1.00	63.5	.200	.100	29.93	18.9	147.7
10	1.677	111023.	.000	.000	1.00	113.9	.200	.100	33.25	18.9	147.7
						100.5	.150	.400			

MODIFIED PARAMETERS:

Eq. Stroke	4.00	(ft)	Efficiency	.95
Pile Cushion Stiffn	0.	(k/in)	Pile Cushion CoR	.50

Rut (kips)	Bl Ct (bpf)	Stroke(eq.) (ft)	min Str (ksi)	i,t	max Str (ksi)	i,t	ENTHRU (kip-ft)
346.2	15.9	4.00	-7.61	(4, 7)	22.23	(3, 4)	75.1
610.5	29.3	4.00	-2.15	(4, 46)	22.33	(4, 4)	75.2

Carruinez Bridge, Pier 5, ICE 220 SH
Goble Rausche Likins & Associates, Inc.

09/11/99
GRLWEAP(TM) Version 1997-2

Depth	(ft)	30.0	Dead Load	(kips)	22.90
Shaft Gain/Loss Factor		.500	Toe Gain/Loss Factor		1.030

PILE PROFILE:

L b Top	Area	E-Mod	Spec Wt	Circmf	Strength	Wave Sp	EA/c
ft	in2	ksi	lb/ft3	ft	ksi	ft/s	k/ft/s
.0	147.66	30000.	492.0	18.9	45.000	16807.	263.6
33.3	147.66	30000.	492.0	18.9	45.000	16807.	263.6

Wave Travel Time 2L/c (ms) 3.957

Pile and Soil Model — Total Capacity Rut (kips) 805.0

No.	Weight	Stiffn	C-Slk	T-Slk	CoR	Soil-S	Soil-D	Quake	LbTop	Circmf	Area
	kips	k/in	ft	ft		kips	s/ft	inch	ft	ft	in2
1	1.677	111023.	.010	.000	.85	.2	.200	.100	3.33	18.9	147.7
2	1.677	111023.	.000	.000	1.00	8.0	.200	.100	6.65	18.9	147.7
3	1.677	111023.	.000	.000	1.00	8.6	.200	.100	9.98	18.9	147.7
4	1.677	111023.	.000	.000	1.00	9.2	.200	.100	13.30	18.9	147.7
5	1.677	111023.	.000	.000	1.00	9.8	.200	.100	16.63	18.9	147.7
6	1.677	111023.	.000	.000	1.00	15.7	.200	.100	19.95	18.9	147.7
7	1.677	111023.	.000	.000	1.00	49.3	.200	.100	23.28	18.9	147.7
8	1.677	111023.	.000	.000	1.00	84.4	.200	.100	26.60	18.9	147.7
9	1.677	111023.	.000	.000	1.00	179.1	.200	.100	29.93	18.9	147.7
10	1.677	111023.	.000	.000	1.00	271.5	.200	.100	33.25	18.9	147.7
						169.5	.150	.400			

MODIFIED PARAMETERS:

Eq. Stroke	4.00	(ft)	Efficiency	.95
Pile Cushion Stiffn	0.	(k/in)	Pile Cushion CoR	.50

Rut	Bl Ct	Stroke(eq.)	min Str	i,t	max Str	i,t	ENTHRU
(kips)	(bpf)	(ft)	(ksi)		(ksi)		(kip-ft)
805.0	41.2	4.00	-1.85	(4, 42)	22.30	(2, 4)	75.0
1458.6	81.3	4.00	-2.56	(7, 18)	22.47	(2, 4)	72.8

Carruinez Bridge, Pier 5, ICE 220 SH
Goble Rausche Likins & Associates, Inc.

09/11/99
GRLWEAP(TM) Version 1997-2

Depth	(ft)	32.0	Dead Load	(kips)	22.90
Shaft Gain/Loss Factor		.500	Toe Gain/Loss Factor		1.030

PILE PROFILE:

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Circmf ft	Strength ksi	Wave Sp ft/s	EA/c k/ft/s
.0	147.66	30000.	492.0	18.9	45.000	16807.	263.6
33.3	147.66	30000.	492.0	18.9	45.000	16807.	263.6

Wave Travel Time 2L/c (ms) 3.957

Pile and Soil Model — Total Capacity Rut (kips) 999.4

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Circmf ft	Area in2
1	1.677	111023.	.010	.000	.85	4.9	.200	.100	3.33	18.9	147.7
2	1.677	111023.	.000	.000	1.00	8.4	.200	.100	6.65	18.9	147.7
3	1.677	111023.	.000	.000	1.00	9.0	.200	.100	9.98	18.9	147.7
4	1.677	111023.	.000	.000	1.00	9.6	.200	.100	13.30	18.9	147.7
5	1.677	111023.	.000	.000	1.00	10.5	.200	.100	16.63	18.9	147.7
6	1.677	111023.	.000	.000	1.00	34.9	.200	.100	19.95	18.9	147.7
7	1.677	111023.	.000	.000	1.00	70.4	.200	.100	23.28	18.9	147.7
8	1.677	111023.	.000	.000	1.00	130.4	.200	.100	26.60	18.9	147.7
9	1.677	111023.	.000	.000	1.00	248.3	.200	.100	29.93	18.9	147.7
10	1.677	111023.	.000	.000	1.00	291.9	.200	.100	33.25	18.9	147.7
						181.2	.150	.400			

MODIFIED PARAMETERS:

Eq. Stroke	4.00	(ft)	Efficiency	.95
Pile Cushion Stiffn	0.	(k/in)	Pile Cushion CoR	.50

Rut (kips)	Bl Ct (bpf)	Stroke(eq.) (ft)	min Str (ksi)	i,t	max Str (ksi)	i,t	ENTHRU (kip-ft)
999.4	53.2	4.00	-1.83	(6, 22)	22.33	(6, 4)	75.0
1836.4	120.0	4.00	-3.47	(6, 17)	22.73	(6, 5)	71.4

FAX TRANSMITTAL

CALIFORNIA DEPARTMENT OF TRANSPORTATION
ENGINEERING SERVICE CENTER
DIVISION OF STRUCTURE FOUNDATIONS
FOUNDATION TESTING & INSTRUMENTATION
5900 Folsom Blvd.
Sacramento, CA 95819

DATE: **10/25/1999**
TOTAL NO. OF PAGES (INCLUDING COVER PAGE): **6**
TO: **Peter Strykers**

PHONE: **510-741-1580**
FAX NO.: **510-741-1750**

Dear Peter,

This transmittal contains a report summarizing the Pile Dynamic Analysis results for Pile 24 at Pier 5 of the Carquinez Bridge Seismic Retrofit Project.

Please feel free to contact me if you have any questions or concerns.

Sincerely,

Brian Liebich

FROM:
Brian Liebich

OFFICE PHONE:
(916) 227-7235

OFFICE FAX:
(916) 227-7244

Foundation Testing & Instrumentation
Caltrans

PAGER:
(916) 592-6117

CALNET:
498-7235

EMAIL:
Brian_Liebich@dot.ca.gov

October 25, 1999

Project Information

04-CC,SOL-80

04-043933

Carquinez Bridge

Br. No. 23-0015R

Subject

Pile Dynamic Analysis: Pile 24 at Pier 5

Introduction

This report presents a summary of Pile Dynamic Analysis (PDA) performed by the Foundation Testing and Instrumentation Branch of the Division of Structural Foundations for Pile 24 at Pier 5 of the Carquinez Bridge Seismic Retrofit. PDA utilizes strains and accelerations, measured during pile driving operations, to assist in determining if a driven pile is overstressed during driving. Pile Driving Analysis was requested at the Carquinez Bridge Seismic Retrofit to assess potential pile damage during driving operations.

Foundation Description

The Carquinez Bridge Seismic Retrofit includes the installation of 48-inch diameter Cast-in-drilled-hole (CIDH) concrete piles with permanent steel casings. The CIDH piles will be installed at Pier 5 to a specified tip elevation of -42.0 feet and a cutoff elevation of 1.25 feet. The permanent casings will be driven to a maximum tip elevation of -32.0 feet.

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Subsurface Conditions

The nearest geotechnical borings of sufficient depth to Pier 5 on the A4E line are Borings B-4H and B-3H, completed in January 1954 by the State of California Division of Highways. The soil indicated by boring logs in the vicinity of Pier 5 between the ground elevation of -1 feet and -15.0 feet is indicated to be primarily very soft blue-black clay with some silt, sand or gravel present. Underlying the clay, at an elevation of -17 to -19 feet, the soil logs indicate a layer of stiff grey sandy clay. Below the sandy clay is shale, described in one boring at the footing as hard to very hard. The Standard penetration blow counts increase with depth, reaching over 100 per foot by elevation -28 feet at one boring.

Pile Installation

The Contractor conducted driving of the 48-inch diameter permanent steel casing for Pile 24 at Pier 5 on October 20, 1999 utilizing an ICE 220-SH single action hydraulic hammer. Characteristics of this hammer include a rated energy of 88 kip-ft at a stroke of 4 feet and a 22 kip ram weight. The hammer submittal for the ICE 220-SH Hammer at Pier 5 was previously reviewed and approved by this Office in a report dated September 28, 1999.

Four strain gauges and two accelerometers were used to monitor the pile stresses and strains. Measured strains and accelerations induced in the pile as a result of driving were used to determine various engineering parameters of interest. Some of the more significant attributes derived for each hammer blow include the maximum pile compressive stresses and hammer performance data such as maximum energy transferred to the pile. Plots depicting these parameters as a function of penetration are presented in Appendix A. Ultimate pile capacity, while possible to calculate utilizing the results of dynamic monitoring, has not been shown to be reliably predicted by PDA for large diameter open-ended pipe piles, and is therefore not presented in this report. Table I summarizes the results for Pile 24 at Pier 5.

Table I - PDA Monitoring Results

Approx. Elevation of Pile Tip at Start of Monitoring	-12 feet
Approx. Elevation of Pile Tip at End of Monitoring	-28 feet
Peak Transferred Energy	72 kip-ft
Maximum Average Compressive Stress	27.4 ksi
Peak Maximum Compressive Stress	35.6 ksi
Blow Counts at End of PDA Monitoring	183 bpf

Discussion

Pile 24 at Pier 5 appears to have been driven without damage while being monitored by Pile Dynamic Analysis. The compressive pile driving stresses measured by PDA did not exceed the allowable stresses within the pile. The peak maximum compressive stress recorded at any gauge was 35.6 ksi. This represents 83% of the allowable stress of 42.75 ksi, which corresponds to 95% of the yield stress for Grade 3 steel. The piles experienced bending as a result of uneven and eccentric blows. While this degree of bending appears acceptable, pile and hammer alignment must be properly maintained to impart maximum energy to the pile and limit the potential for pile damage..

Pile 24 was not monitored in the final four feet of driving, below a penetration of 23 feet, corresponding approximately to an elevation of -28 feet, as a result of no provisions being made to protect the PDA instrumentation below this depth. Therefore, this Office cannot provide an analysis of pile driving conditions below elevation –28 feet. Measurements of blow counts in the final four feet of driving did indicate an increase in resistance to driving, with 206 blows measured per 6 inches upon termination of driving, about 6 inches above specified tip elevation.

Recommendations

The results of dynamic monitoring performed on Pile 24 indicate that the pile was driven by the ICE 220-SH without damage and within the stress limits while the pile was being monitored. However, the rate of penetration was less than the required set of 1/8-inch per blow, equivalent to 96 blows per foot, below an approximate elevation of -25 feet for this pile. As the pile does not appear to be overstressed, some potential does exist to utilize a larger hammer to drive the piles.

If an alternate hammer is selected to drive the piles to the specified tip elevation, this Office recommends that additional pile dynamic monitoring be performed to verify that the new hammer does not overstress the pile during driving. Additionally, as pile driveability is highly dependent upon soil characteristics, hammer alignment, pile length, pile handling, the integrity of the pile cushions, and adherence to the specifications and industry-accepted driving practices, engineering judgement should be applied before applying this information to other piles driven at the site.

If you have any questions or comments, please call me at (916) 227-7235 or Calnet 498-7235.

Brian Liebich

BRIAN LIEBICH
Transportation Engineer, Civil
Foundation Testing & Instrumentation Branch
Office of Geotechnical Support

REGISTERED PROFESSIONAL
DANIEL H. SPEER
No. CE 42994
Exp. 3/31/00
CIVIL ENGINEER
STATE OF CALIFORNIA

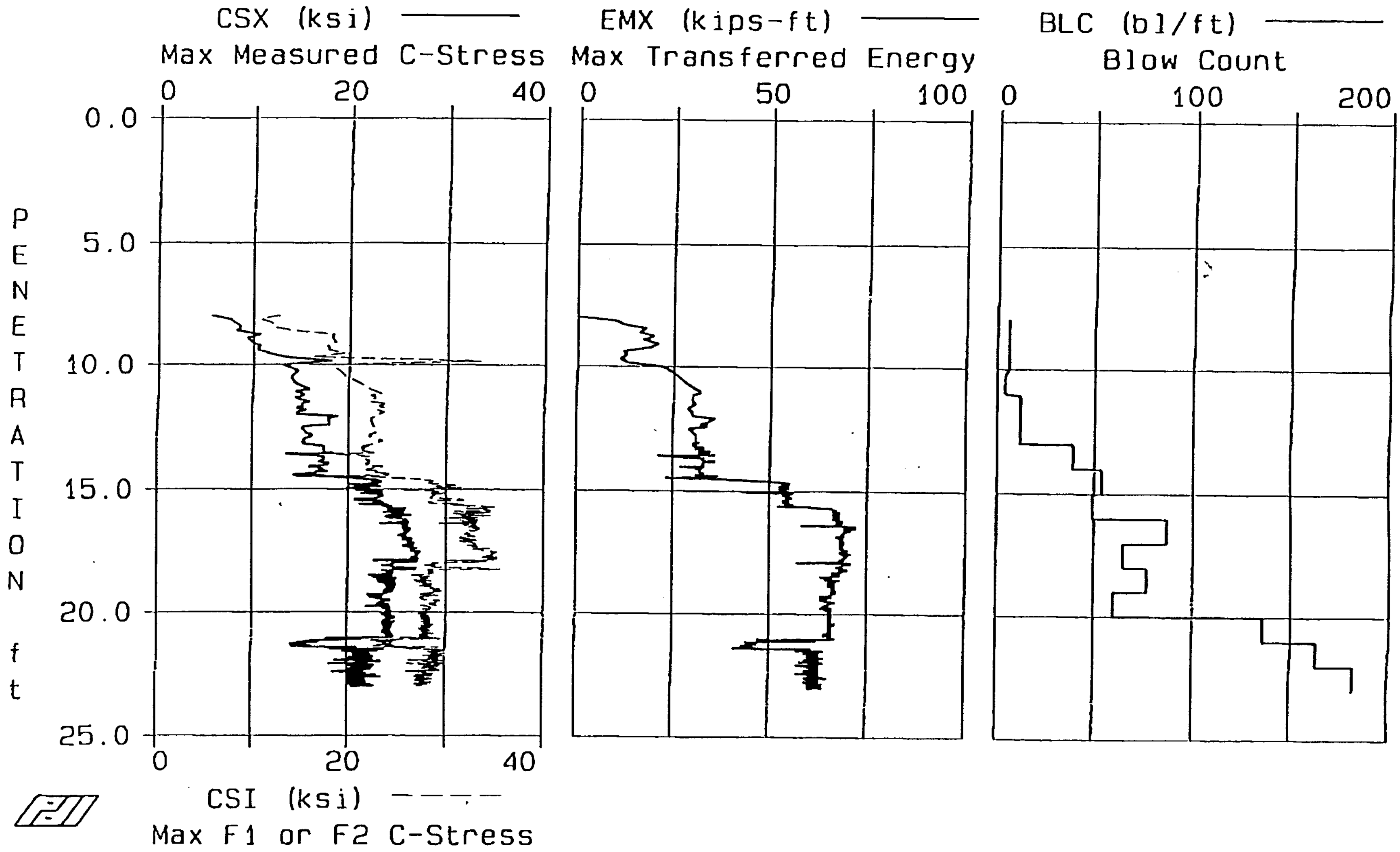
DANIEL SPEER, P.E.
Senior Materials and Research Engineer
Foundation Testing & Instrumentation Branch
Office of Geotechnical Support

Caltrans

California D.O.T.

20-Oct-99

Carquinez Bridge Seismic Retrofit - Pier 5 Pile 24 - ICE 220 SH



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-CAL TRANS -

DEPARTMENT OF TRANSPORTATION
PILE LAYOUT SHEET
DH-OS C80 (REV. 11 73)

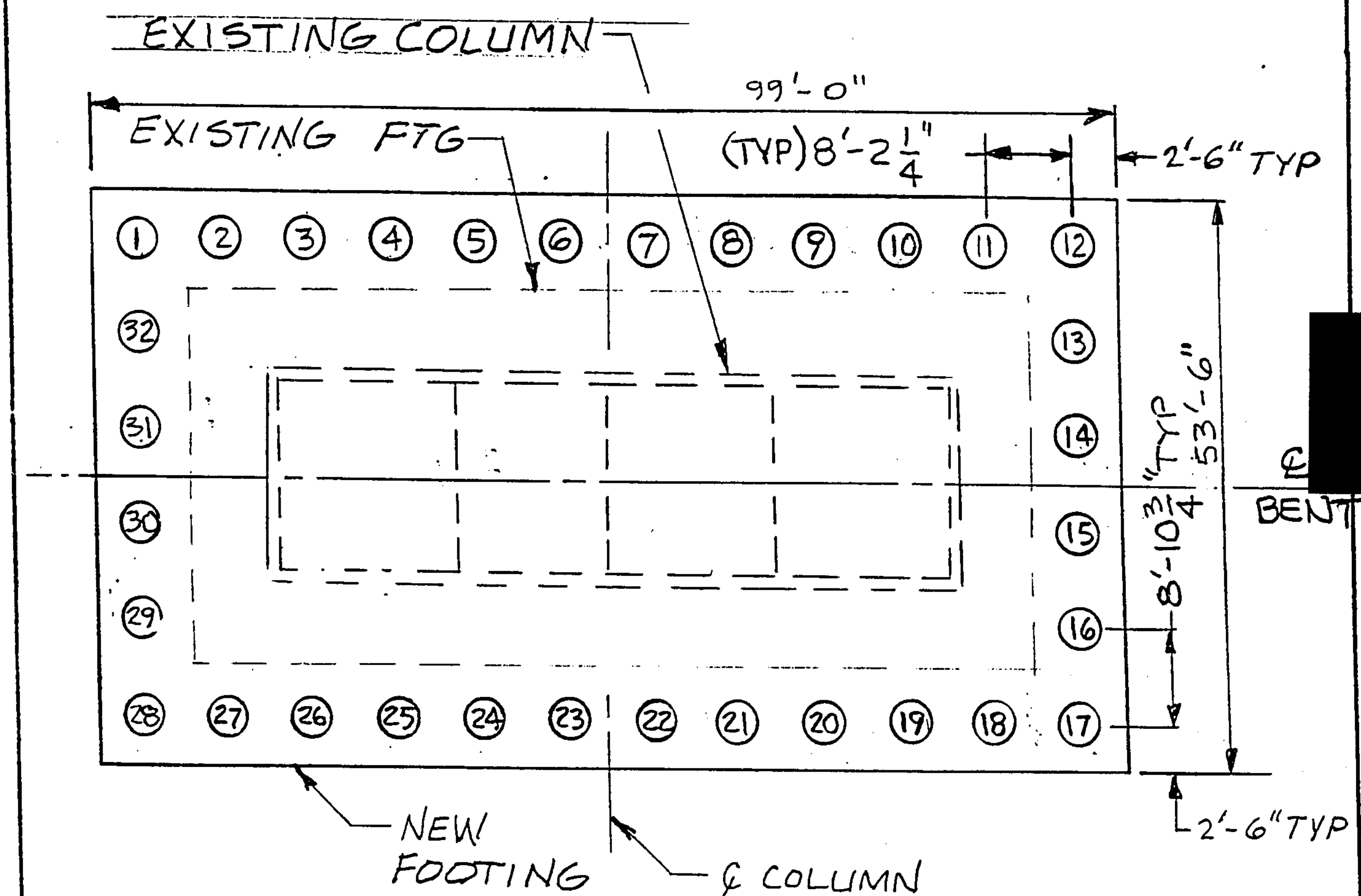
JOB STAMP
At Crockett & In Vallejo From Cummings
Skyway Overcrossing To Carquinez
Bridge Toll Plaza

Drawn By DMEISELMAN Date 10-15-98 Sheet No 1 OF 1

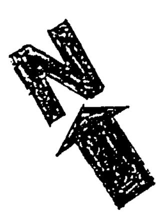
Checked By JR Date 10-15-98

Bridge No 23-15R Bridge Name CARQUINEZ BRIDGE "A4E" LINE-MS

Abutment or Bent No PIER 5 Ftg ______ Ftg Type ______ Bot Ftg Elev -3.00±



FOOTING PLAN - PIER NO. 5



SCALE ______

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04-043934
04-CC,Sol-80-12.8/14.1,0.0/0.6
Contra Costa & Solano Counties
At Crockett & In Vallejo From Cummings
Skyway Overcrossing To Carquinez
Bridge Toll Plaza

DEPARTMENT OF TRANSPORTATION

LOG PILE SHEET

DH-OS C79 (REV. 11 73)

10/21/99 A.M.

Bridge No 23-15R Abut or Bent No Pier 5 Ftg X Pile No 23 Sheet No 1

Hammer Make ICE Model 220 E = 22000 Ft-Lbs

Reference Point-Description BOF = (ELEV -3) Elev -3.00'

STROKE	PENET	TIP ELEV	BLOWS / FT
1'	9	-12	2
2'	10	-13	8
2'	11	-14	10
2'	12	-15	13
2.5'	13	-16	18
3'	14	-17	25
3.5'	15	-18	37
4'	16	-19	46
4'	17	-20	71
4'	18	-21	75
	19	-22	79
	20	-23	95
	21	-24	125
	22	-25	134
	23	-26	195
	24	-27	280
	25	-28	313
	25.5 26	-28.5	190 STOP.
	27		
	28		

PENET	TIP ELEV	BLOWS / FT

PENET	TIP ELEV	BLOWS / FT

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04-043934
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Contra Costa & Solano Counties
At Crockett & In Vallejo From Cummings
Skyway Overcrossing To Carquinez
Bridge Toll Plaza

DEPARTMENT OF TRANSPORTATION

LOG PILE SHEET

DH-OS C79 (REV. 11 73)

Bridge No 23-15R Abut or Bent No PIER 5 Ftg X Pile No 24 Sheet No 1

Hammer Make ICE Model 220 E = 22000 Ft-Lbs

Reference Point-Description ~~[illegible]~~ BOTTOM OF PIER 5 FOOTING Elev -3.00' ±

	PENET	TIP ELEV	BLOWS / FT
	1	PUSH	
	2	↓	
	3		
	4		
	5		
	6		
	7		
	8		
	9		
2-FT STROKE	10		8
↓	11		9
	12		15
	13		24
	14		28
2-3FT	15		48
3-3½	16		47
	17		[illegible]
3½	18		54
3½	19		~~44~~ 55
3½-4 ~~[illegible]~~	20		~~[illegible]~~ 71
4 FT	21		99
4 FT	22		96
4-3½	23		161
4 FT	24		164
4 FT	25		197
〃	26		281
〃	27		324
〃	28		409
〃	29	-31.5'	204 @6" penetration

6" more to design tip (-32')

PENET	TIP ELEV	BLOWS / FT
30		
31		
32		
33		
34		

PENET	TIP ELEV	BLOWS / FT